Lightweight Superconducting Magnets for Low Temperature Magnetic Coolers, Phase II

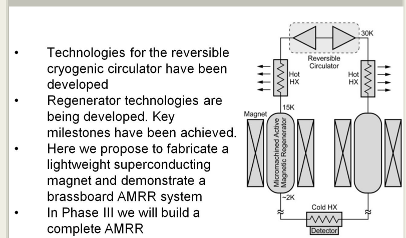
Completed Technology Project (2014 - 2019)

Project Introduction

NASA's future science missions to investigate the structure and evolution of the universe require efficient, very low temperature coolers for low noise detector systems. We propose to develop a highly efficient, lightweight Active Magnetic Regenerative Refrigeration (AMRR) system that can continuously provide remote/distributed cooling at temperatures of about 2 K with a heat sink at about 15 K. The AMRR system uses three novel design features to achieve a large cooling capacity and very high thermal efficiency: a vibration-free, reversible cryogenic circulator; innovative micromachined regenerators; and lightweight superconducting magnets. The superconducting magnet uses low-current superconducting wires and a unique winding arrangement to enable an AMRR system to achieve high thermal efficiency. In Phase I, we selected an optimum superconducting material for the magnet and developed its electrical and structural support subsystems. Based on the performance characteristics of the magnet, we optimized the magnetic field and showed by analysis that the AMRR system driven by such a magnetic field will be able to achieve high efficiency. In Phase II, we will build and characterize a superconducting magnet, assemble a brassboard AMRR system with a circulator and an active magnetic regenerator, and demonstrate the system performance under prototypical conditions. In Phase III, we will assemble a fully integrated Engineering Model AMRR system and demonstrate its performance.

Anticipated Benefits

The proposed AMRR system will enable NASA to carry out future space astronomy missions that use cryogenic infrared, gamma ray, and X ray detectors. These detectors need to operate at temperatures in the range of 4 K to below 1 K to reduce the thermal emission of the detectors themselves and to achieve high sensitivity and resolution. The vibration-free, lightweight AMRR can provide efficient cooling for these missions at the required temperature ranges. The fabrication technologies developed for the lightweight superconducting magnets can also be applied to the fabrication of advanced magnets for multistage active demagnetization refrigerators (ADRs), particle accelerators, and portable MRIs.Military applications for the proposed magnetic cooler include cooling systems on space-based surveillance, missile detection, and missile tracking systems. Scientific applications include cooling systems for material microanalysis using X ray microcalorimeter spectrometers, superconducting radio frequency cavities, superconducting cavities, and superconducting digital electronics.



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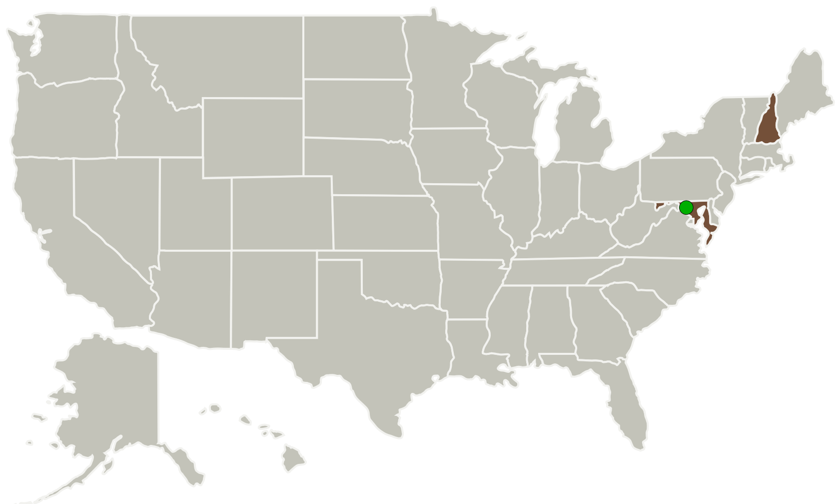
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Creare LLC	Lead Organization	Industry	Hanover, New Hampshire
Goddard Space Flight Center(GSFC)	Supporting Organization	NASA Center	Greenbelt, Maryland

Primary U.S. Work Locations	
Maryland	New Hampshire

Project Transitions

April 2014: Project Start

May 2019: Closed out

Closeout Documentation:
- Final Summary Chart PDF*(https://techport.nasa.gov/file/137617)*

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Creare LLC

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Project Managers:

Joseph Famiglietti
Edgar R Canavan

Principal Investigator:

Weibo Chen

Co-Investigator:

Weibo Chen

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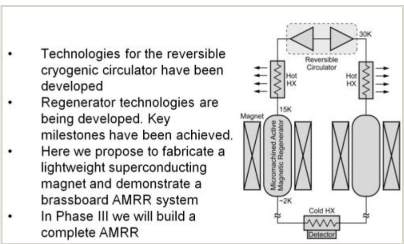
Completed Technology Project (2014 - 2019)

May 2019: Closed out

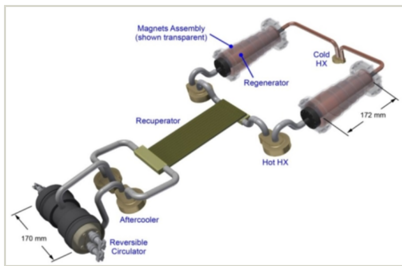
Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/137618)*

Images



Briefing Chart Image
Lightweight Superconducting Magnets for Low Temperature Magnetic Coolers, Phase II
(https://techport.nasa.gov/image/136836)



Final Summary Chart Image
Lightweight Superconducting Magnets for Low Temperature Magnetic Coolers, Phase II
(https://techport.nasa.gov/image/128686)

Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **4**

1 2 3 4 5 6 7 8 9

Applied Research | Development | Demo & Test

Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System